ERDC/CHL CHETN-III-80
August 2010

US Army Corps of Engineers®

A Review of Coastal Navigation Asset Management Initiatives Within the Coastal Inlets Research Program (CIRP) Part 1: Coastal Structures

by Kenneth Ned Mitchell

PURPOSE: This is the first Coastal and Hydraulics Engineering Technical Note (CHETN) in a series summarizing research initiatives underway since fiscal year (FY) 2007 within the Coastal Inlets Research Program (CIRP) concerning asset management of coastal navigation structures and channels. This CHETN describes the Coastal Structures Management, Analysis, and Ranking Tool (CSMART), a decision-support package for prioritizing coastal structures for annual maintenance funding that has been developed within the CIRP's Coastal Navigation Portfolio Management (CNPM) work unit.

BACKGROUND AND OVERVIEW: The U.S. Army Corps of Engineers (USACE) has had a formal Asset Management (AM) program in place since FY2006. This is a Headquarters (HQ) initiative intended to provide an all-encompassing, systematic framework for risk-informed life-cycle management of civil works assets owned and maintained by the Corps (USACE Asset Management Plan, 2008). The AM philosophy applies to all phases of a project's life cycle, from planning and construction through periodic maintenance and upkeep, major rehabilitation(s), and eventual divestment. At each phase, the project is evaluated in terms of risks and consequences of failure, and funding decisions are made so as to maximize the return on investment over the anticipated project life cycle. One caveat to this approach is that present funding realities within the Corps compel decision makers to allocate limited resources towards only those projects deemed most critical to fulfillment of the USACE mission. Several issues are driving the funding shortfalls, including the reduction in funds released from the Harbor Maintenance Trust Fund (HMTF) over the last several years (GAO 2008). Therefore, adoption of the AM approach should be made with the understanding that investment decisions will be made based upon a project's *relative* performance against all others in the USACE portfolio.

Since its inception, the USACE-HQ AM initiative has worked with the Corps R&D community and District and Division personnel to develop tools and strategies for implementation of the asset management philosophy into the Corps business practice. The research initiatives described herein have been supported solely by the Corps' Navigation Business Line through annual R&D funding, and represent a good-faith effort to be proactive in adopting the asset management philosophy for operations and maintenance (O&M) of the coastal navigation infrastructure. The primary mission of the CIRP is to conduct research and develop tools for reducing the costs of maintaining Federal navigable coastal inlets and channels (Hughes and Kraus, 2006), making it well suited for the task of applying AM methods to the USACE coastal navigation portfolio.

In keeping with the spirit of the AM initiative as it pertains to coastal navigation infrastructure, the CIRP established a Coastal Structures Asset Management work unit in FY 2007. Initial

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **AUG 2010**	2. REPORT TYPE	3. DATES COVERED
4. TITLE AND SUBTITLE **A Review of Coastal Navigation Asset Management Initiatives Within the Coastal Inlets Research Program (CIRP) Part 1: Coastal Structures**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Engineer Research and Development Center,Coastal and Hydraulics Laboratory,3909 Halls Ferry Road ,Vicksburg,MS,39180-6199**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**16**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

efforts included a qualitative survey of the USACE inventory of coastal jetty and breakwater structures, with emphasis placed on the economic consequences of structural failure and functional degradation. This study relied heavily upon the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program's coastal structures case studies conducted in the late 1980's (Bottin and Sargent, 1988) as well as the CIRP Coastal Structures Database to establish the preliminary inventory of structures to be evaluated. Economic significance of coastal structures was estimated based largely upon published tonnage statistics from the Corps' Waterborne Commerce Statistics Center (WCSC), but also upon other metrics such as commercial fish landings and cruise and ferry passenger statistics gathered from other government sources. The results of this modest effort were presented at the Infrastructure Systems Conference (ISC) held in Detroit in June 2007, and they highlighted the need for an objective, transparent basis by which coastal jetty and breakwater structures could be prioritized for annual O&M funding.

To address this issue, beginning in FY 2008, the work unit began development of a software application that would aggregate the myriad data sources pertaining to the economic significance of coastal jetty and breakwater structures. The software package is called the Coastal Structures Management, Analysis, and Ranking Tool (CSMART), and it uses data from several publicly-available government sources to compile indicators of significance for each structure and produce a ranked listing that reflects decision-maker priorities. Details of the CSMART data sources and approach will be given later in this technical note.

In June of 2008 a coastal structures asset management workshop was held in Chicago to bring together District, HQ, and R&D representatives for discussions on how to rationally and transparently allocate limited funding towards maintenance and rehabilitation of Corps jetties and breakwaters. This workshop was organized and facilitated jointly between the CIRP and the Navigation Systems research program. In addition to CSMART, several other R&D tools pertaining to coastal structures asset management were presented, including the Enterprise Coastal Inventory Database (ECID), the Coastal Structures Condition Assessment (CoSCA) tool, and a life-cycle analysis toolbox for evaluating major rehabilitation alternatives for breakwaters. Representatives from the Navigation Business Line at USACE-HQ were pleased with the straightforward data-management approach taken by CSMART for prioritizing of projects for maintenance funding, and as a direct result of this workshop enquired as to whether a similar tool could be developed on short suspense to focus specifically on deep-draft navigation channels. Due to the high-priority, fast-track nature of the request, CSMART upgrades and refinements were put on hold, to be resumed at a later date once the decision-support tool for channels (later named the Channel Portfolio Tool; CPT) was firmly established. As a result, work did not resume on CSMART until FY2010, as discussed below.

In February 2010, the CNPM work unit was asked to oversee completion of a proof-of-concept decision-support tool for prioritizing coastal structures for maintenance funding across the entire USACE portfolio. This tool had been requested by the USACE-HQ AM initiative at the beginning of FY2010 based on input from the Coastal Structures Board of Advisors (CSBA), a panel of coastal engineers and operations personnel from several Corps Districts and ERDC that formed in FY2007. Though the initial request called for a completely new software tool to be designed, CSBA members eventually acknowledged that simply adding some new capabilities to the existing CSMART package represented a more efficient long-term approach. Therefore the

remaining funds have been directed to include additional consequence metrics in the CSMART framework, as well as some first-order structure condition data gathered from District personnel. The details of these upgrades will be discussed later in the technical note.

At the National Dredging meeting in Washington, D.C. in May of 2010, CSMART was given prominent coverage during a session focused on asset management of the Corps navigation portfolio. This indicates that CSMART has effectively demonstrated its utility to decision makers at all levels of USACE management in applying the asset management philosophy to the coastal structures portfolio.

CNPM DEVELOPMENT PLAN: The efforts of the CNPM work unit have resulted in both CPT and CSMART being in position to play important roles within a comprehensive asset management framework for the USACE coastal navigation portfolio. Development plans call for CSMART to be transitioned from its present stand-alone format to a web-based platform to ensure ready access for District users. To the extent practical, this process will include a merger of the respective software interfaces into a single, comprehensive decision-support package for asset management of the USACE navigation portfolio.

The CNPM development plan also calls for linking CPT and CSMART with other initiatives underway within USACE in support of the Navigation mission. One such linkage will allow for the Automatic Identification System (AIS) data feed from the US Coast Guard (USCG) to provide up-to-date vessel counts within maintained channels and near structures. The AIS technology has great potential for providing an automated mechanism for evaluating the functional performance of coastal structures. For example, archiving and subsequent analysis of the vessel track data feed could provide a means to identify unusual characteristics that are indicative of adverse current conditions or channel shoaling. Early, automated detection of such events would allow USACE to more effectively allocate maintenance funding to those locations most in need.

COASTAL STRUCTURES INVENTORY AND O&M CURRENT PRACTICE: According to the ECID, there are over 900 individual coastal structures owned and maintained by USACE. The vast majority of these is rubble mound or laid stone structures, but there are other types as well such as timber cribs and pilings, sheetpile walls, cribs, and bulkheads, and poured concrete pilings and caissons. In terms of function, the coastal structures inventory consists primarily of jetties (384) and breakwaters (362), with stabilization revetments, beach groins, and seawalls comprising the rest. The average age for coastal structure in the Corps inventory is roughly 60 years, with a significant number of structures (83) exceeding 100 years in age. The distribution of coastal structures across the 8 USACE Divisions is given in Table 1.

With limited outlays from the HMTF, funding for coastal structures O&M has been significantly reduced in recent years. In FY 2010, out of $145.7 million requested for coastal structures O&M by the Corps Districts, only $19.5 million was awarded. Of this funding that was allocated, roughly 43 percent was directed toward structures belonging to the 59 projects that exceed 10 million commercial tons annually. The strained funding environment for coastal structures is compounded by the extreme expense often associated with major rehabilitation efforts. With some exceptions, most structures have been allowed to deteriorate over the decades such that

now only major reinvestments, on the order of tens of millions of dollars per structure, will return them to their original as-built condition.

Table 1. Distribution of coastal structures across USACE Divisions, according to ECID.

Division	Total # of Structures	# of Jetties	# of Breakwaters	# of Other Types	Average Age (years)
Lakes & River Division	315	106	155	54	64
Mississippi Valley Division	26	24	1	1	56
North Atlantic Division	219	113	73	33	69
Northwest Division	74	31	30	13	61
Pacific Ocean Division	88	8	55	25	45
South Atlantic Division	75	47	16	12	59
South Pacific Division	97	37	28	32	54
Southwest Division	26	18	4	4	55

COASTAL STRUCTURES MANAGEMENT, ANALYSIS, AND RANKING TOOL (CSMART): A rational basis is needed for allocating O&M funding across the vast USACE inventory of coastal structures. Given that budgetary constraints prevent all maintenance needs from being met, the Corps needs a way to objectively prioritize coastal structures in terms of their physical condition and the consequences of their failing to perform as designed. Though straightforward in concept, this proves to be a challenging undertaking when one attempts to factor in the myriad functional roles that coastal structures often play, as well as the assortment of maritime industries that depend upon that functionality. To put the problem into perspective, consider a typical pair of jetties protecting an entrance channel providing access to a coastal port. These jetties help to focus natural tidal currents so as to maintain scour action in the navigation channel, thereby maintaining navigable depths for commercial shipping and reducing annual dredging requirements. Additionally, the jetties provide protection within the entrance channel from adverse wave and current conditions that could affect both deep-draft commercial shipping as well as smaller vessels that also utilize the port, such as commercial fishing vessels, passenger ferries, and recreational craft. Failure of the jetties to function as designed (due to degraded condition, a large storm event, or shifting hydraulic conditions) could result in increased shoaling rates within the channel and a subsequent increase in USACE dredging costs. Additionally, the loss of adequate channel depths could force deep-draft vessels to light-load or call upon other harbors instead, leading to increased shipping costs and economic losses for the industries utilizing the port. Likewise, if adverse wave or current action occurs within the jettied entrance channel, the operations of other supported maritime industries (commercial fishing, ferries, etc.) will be disrupted, and there will be an increased risk of accidents within the channel. It is clear that all of these maritime stakeholders depend upon the functioning jetties to ensure reliable access to the port, yet quantifying the degree of that dependency remains a challenge, especially when extended across the entire portfolio of structures. The simplified example presented above is but one case, and there are hundreds of others nationwide that similarly depend upon USACE coastal structures to ensure reliable, safe maritime operations. The challenge presented to Corps decision makers is how to rationally and objectively allocate limited maintenance funding such that national, regional, and local needs are met to the greatest extent possible.

The CSMART application provides a straightforward, transparent means of prioritizing the inventory of USACE coastal structures. Given the complex economic systems dependent upon

coastal structure functionality, as well as the sheer number of structures in the Corps navigation portfolio, the only feasible way to objectively rank structures nationwide for annual O&M funding is through the use of *indicators* of economic significance and project performance. Several independent analyses conducted in recent years of USACE business practices have recommended this very same indicator-based approach for improving the overall efficiency of the Corps' management of the national water resources infrastructure (TRB 2004; O'Keefe et al., 2007).

USACE personnel do not have the time or resources to conduct detailed economic analyses and structural condition assessments for all coastal structures, and doing so still would not provide a consistent, objective basis of comparison necessary for prioritizing funding needs across the entire project portfolio. Therefore CSMART pulls indicators of significance (to be listed and discussed below) of coastal structures from several publicly-available sources of information. For several data sets, latitude and longitude coordinates for each structure are taken from the ECID and used to conduct an automated spatial match such that structures are associated with appropriate data entries. The CSMART user is able to select which indicators are to be included within the final prioritization framework. Once structures under consideration have been selected and relevant metrics chosen, CSMART queries the underlying database and returns a ranked listing of structures. The user is able to assign weightings to each chosen indicator so as to better reflect decision maker priorities and/or policy goals.

Some discussion is in order to ensure that the CSMART approach outlined above is properly understood within a broader asset management context. As described previously, the AM initiative at USACE-HQ seeks to adopt risk-informed decision practices for application at all stages of project life cycle. In this context, CSMART should not be thought of as an all-encompassing, asset management tool for all stages of coastal structure life-cycle. Rather, the indicator-based approach that CSMART employs is designed specifically for prioritizing annual O&M funding allocations across a given inventory of coastal structures. Annual O&M funding per project is modest compared to the sums required for new construction or major rehabilitation, and the rolling budget cycle employed by USACE leaves decision makers with little time or resources for rigorous, detailed evaluations on a project-by-project basis. For these reasons, CSMART is well-suited for providing decision support to Corps personnel tasked with the annual allocation of limited O&M funding. Moreover, CSMART should not be considered as a planning tool, though it can provide significant historical data that could be useful for informing certain planning decisions. Likewise, major reinvestment decisions concerning extensive structure rehabilitation should only be made after conducting thorough condition inspections, functional performance assessments, and detailed economic analyses to ensure that the high costs are justified. The Navigation Systems Research Program has developed several tools to assist in just these sorts of investigations, including the Hand-held Inspection Tool (HHIT), and the previously-mentioned CoSCA tool and life-cycle toolbox for breakwaters.

CSMART DATA SOURCES

Commercial Tonnage: Commercial waterborne tonnage statistics are gathered and published annually by IWR's Navigation Data Center (NDC) through the WCSC mentioned previously. The reports are entitled Waterborne Commerce of the United States and are available online here: *http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm*. Using the port-level data contained in

these reports, CSMART presents the commercial tonnage accommodated by coastal structures, complete with filters for foreign and domestic traffic, commodity type, and direction of transit. Efforts have been made to ensure that only the tonnage directly supported by a given coastal structure (e.g. shipments passing through a jettied entrance channel or docking behind a breakwater) is counted towards its economic significance. In most instances only foreign and coastwise and lakewise domestic traffic is considered to be directly supported by coastal structure functionality. Also, in some instances, a particular structure may support access to more than one coastal port facility (e.g. Galveston Entrance and Southwest Pass jetties), and in such cases the tonnage figures for all dependent ports are added into one cumulative score for that structure. Conversely, for some port areas the coastal structures in question may only protect certain reaches, or may not support commercial navigation directly (e.g. breakwaters protecting small boat harbors). To avoid overstating the support given by individual coastal structures to commercial shipping, whenever possible the ECID and REMR reports have been used to pinpoint the exact locations of structures within a given port area and determine the extent to which they support commercial navigation. One final point concerning commercial tonnage as a measure of economic function deals with the fact that the majority of Corps coastal structures are found in port areas without any significant commercial tonnage recorded by the WCUS. This underscores the need to look for additional measures of economic significance when evaluating coastal structures for O&M funding.

Commercial Fishing Data: Commercial fishing generates significant economic activity in many parts of the country, with some ports receiving a yearly catch in excess of $100 million. Corps coastal structures, particularly breakwaters protecting harbors and marinas, help sustain this industry by providing docking ports and harbors of refuge for the US commercial fishing fleet. The National Oceanic and Atmospheric Administration (NOAA) provides statistics on commercial fishing for individual US ports through its National Marine Fisheries Service (NMFS). The statistics typically describe the commercial seafood catch in terms of poundage and dollar value. One online data source for such information for US ports going back to 1980 can be found here: *http://www.st.nmfs.gov/st1/commercial/landings/lport_hist.html*. NOAA personnel provided the commercial fish landings data for use within the CSMART application. Though not included online in the link above, data pertaining to Great Lakes fishing was included as well. NOAA personnel explained that the fishing ports listed in the database typically represent wholesale seafood buyers, and that there could be several fishing communities in the region represented by the data for those ports. Therefore, CSMART performs a spatial search and matches any Corps jetties and breakwaters within a 15-mile radius to the commercial fish totals for each port. Future iterations of development will refine this approach to ensure that structures are appropriately credited with the support they give to local commercial fishing activities.

U.S. Coast Guard (USCG) Incident Reports: The USCG maintains detailed records concerning accidents that take place in US waters. The NDC receives these data each year and posts them to its online directory: *http://www.ndc.iwr.usace.army.mil/data/datauscg.htm*. The USCG incident reports database contains information such as type of accident (e.g. collision, grounding, fire, etc.) and injury reports (e.g. deaths, injuries, missing persons) and includes geo-coordinates for most entries. CSMART reads these data and performs a spatial search to associate nearby incidents to respective coastal structures. It should be noted that this database alone does not contain enough information to determine whether the structural performance of a

given jetty or breakwater in any way contributed to a particular incident. Rather, in keeping with the overall approach taken by CSMART towards prioritization of the coastal structures portfolio, inclusion of the USCG incidents database is meant to provide yet another potential indicator of significance by which structures may be compared.

Dredging Information System (DIS): The NDC maintains the DIS primarily as a business tool for the Corps Districts as well as dredging industry groups. The DIS contains scheduling and contracting data for all dredge jobs conducted by Corps and industry-owned vessels. The data is available online at: *http://www.ndc.iwr.usace.army.mil/data/datadrgsel.htm*. CSMART uses this data to include dredging activities near coastal structures within a decision-making framework. As with the other indicators discussed in this technical note, no single entry makes the case for the significance of a given structure. However, when these indicators are considered in combination and looked at in an aggregate sense, it is thought that structures with legitimate economic roles worthy of consideration will be brought to the attention of decision makers.

Structure Condition Ratings: Members of the Corp's CSBA have recently obtained first-order condition ratings for most structures in the navigation portfolio, and these have been loaded into the revised version of CSMART for delivery to the USACE-HQ Asset Management initiative. These ratings are simple, "red, yellow, green" assessments, typically obtained through phone and e-mail correspondence with District personnel. To be sure, there is subjectivity present in these ratings and they need to be checked and validated for accuracy. However, this initial batch of ratings loaded into CSMART nonetheless provides a basis for prioritization that includes both structural condition and the potential consequences of structural failure.

USACE Project Use Codes: The Navigation Business Line at USACE-HQ keeps an updated record of project usage codes to help track the importance of active projects to the overall Corps navigation mission. These usage codes indicate which projects serve as harbors of refuge, subsistence harbors, or public transportation (i.e. passenger ferry) terminals. These usage indicators are especially important for smaller ports and harbors lacking significant commercial tonnage.

CSMART INTERFACE AND SAMPLE RESULTS: CSMART runs as a stand-alone application on a desktop computer, and can be downloaded via the CIRP website: *http://cirp.usace.army.mil/products/index.html*. Once installed and initiated, CSMART prompts the user on whether to include each of the various indicators of significance discussed previously. Figure 1 shows the initial screen of the CSMART interface, allowing the user to specify any desired data filters concerning commercial tonnage.

A similar data filter specification screen is shown by clicking on each of the respective indicator tabs near the top of the screen. Note that data filters cannot be specified until the toggle box in the top left of each screen has been checked, telling CSMART to include that indicator in the final rankings. Figure 2 shows the same type of screen for Coast Guard incident reports.

Note that the user may actually specify a search radius around each structure within which to associate incidents of record. This gives the user more control concerning how strict the spatial matching step needs to be, depending on user preferences.

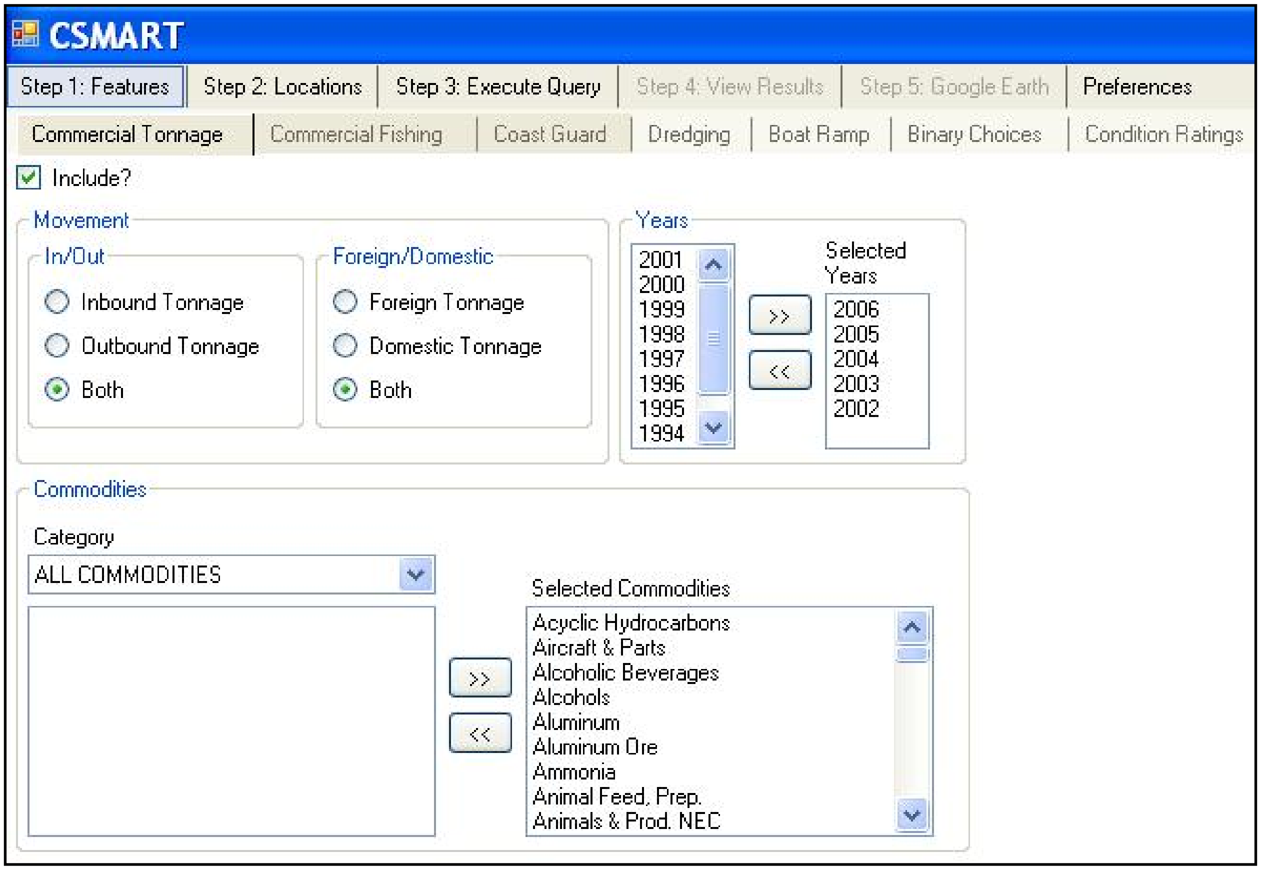


Figure 1. CSMART interface for commercial tonnage.

Once all desired indicators have been selected and appropriate data filters enabled, the user may select the list of structures to be ranked. Figure 3 shows the CSMART structure selection screen.

The user may choose to select from structures within a particular District or Division, but can also select from all structures in the USACE portfolio. Once all structures under consideration have been specified, the user clicks on the "Step 3. Execute Query" tab to initiate the ranking process, which typically takes from 5 to 10 seconds to complete. The user may then view results (Step 4 tab), and see structures ranked according to the individual indicators (tonnage, commercial fishing, etc.) or cumulatively, with each indicator given an appropriate weighting. Figure 4 shows the CSMART-produced rankings of coastal structures nationwide in terms of supported commercial tonnage for 2006.

The commercial tonnage supported by each coastal structure is shown along with parent project, State, and structure name. Rankings are given for both individual structures as well as projects. By clicking on the small box in the Details column on the left-hand side, the user will open a separate window offering additional details on the tonnage totals. Figure 5 shows the tonnage details CSMART page for the Southwest Pass jetties.

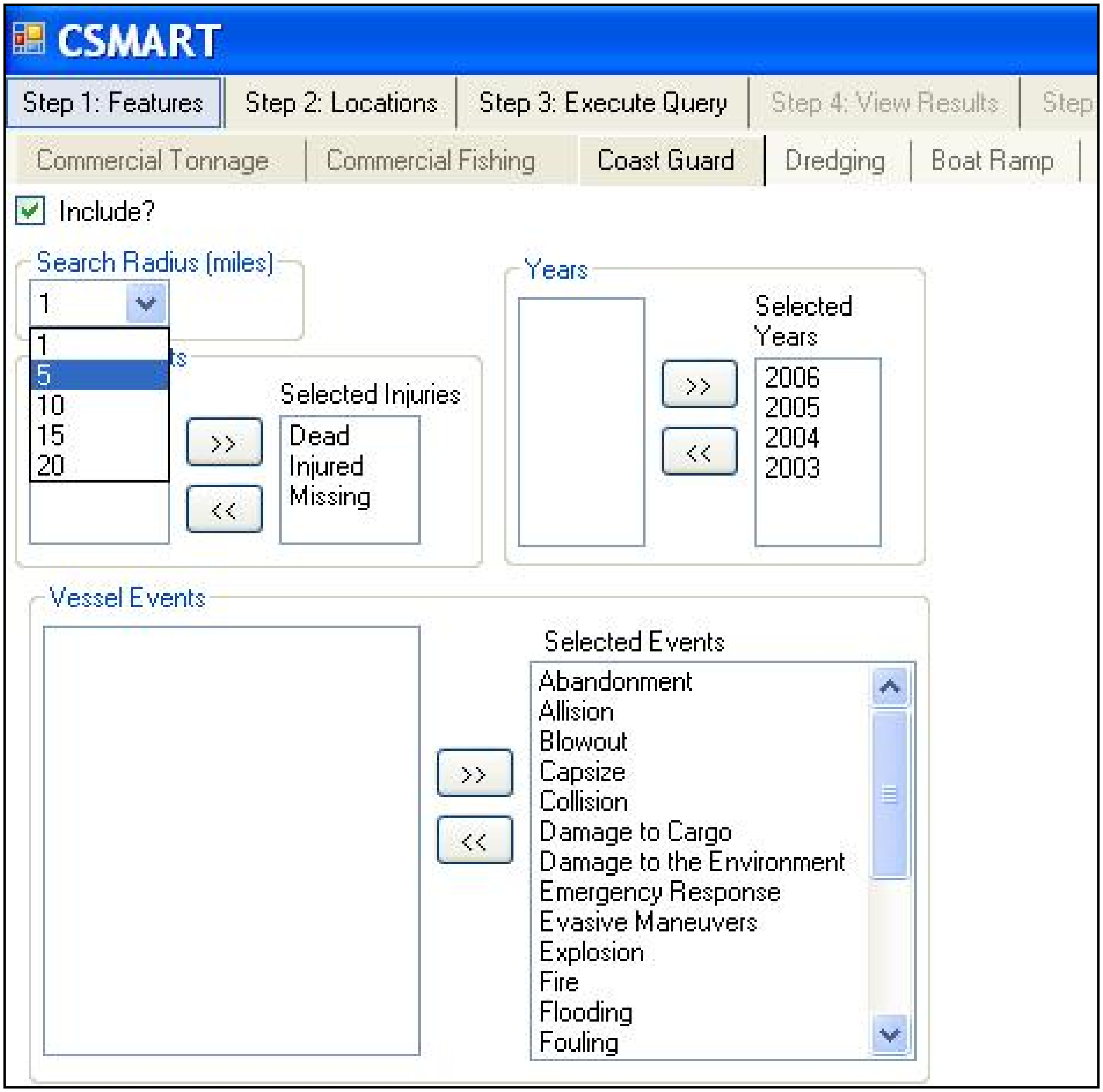


Figure 2. CSMART interface for coast guard incident reports.

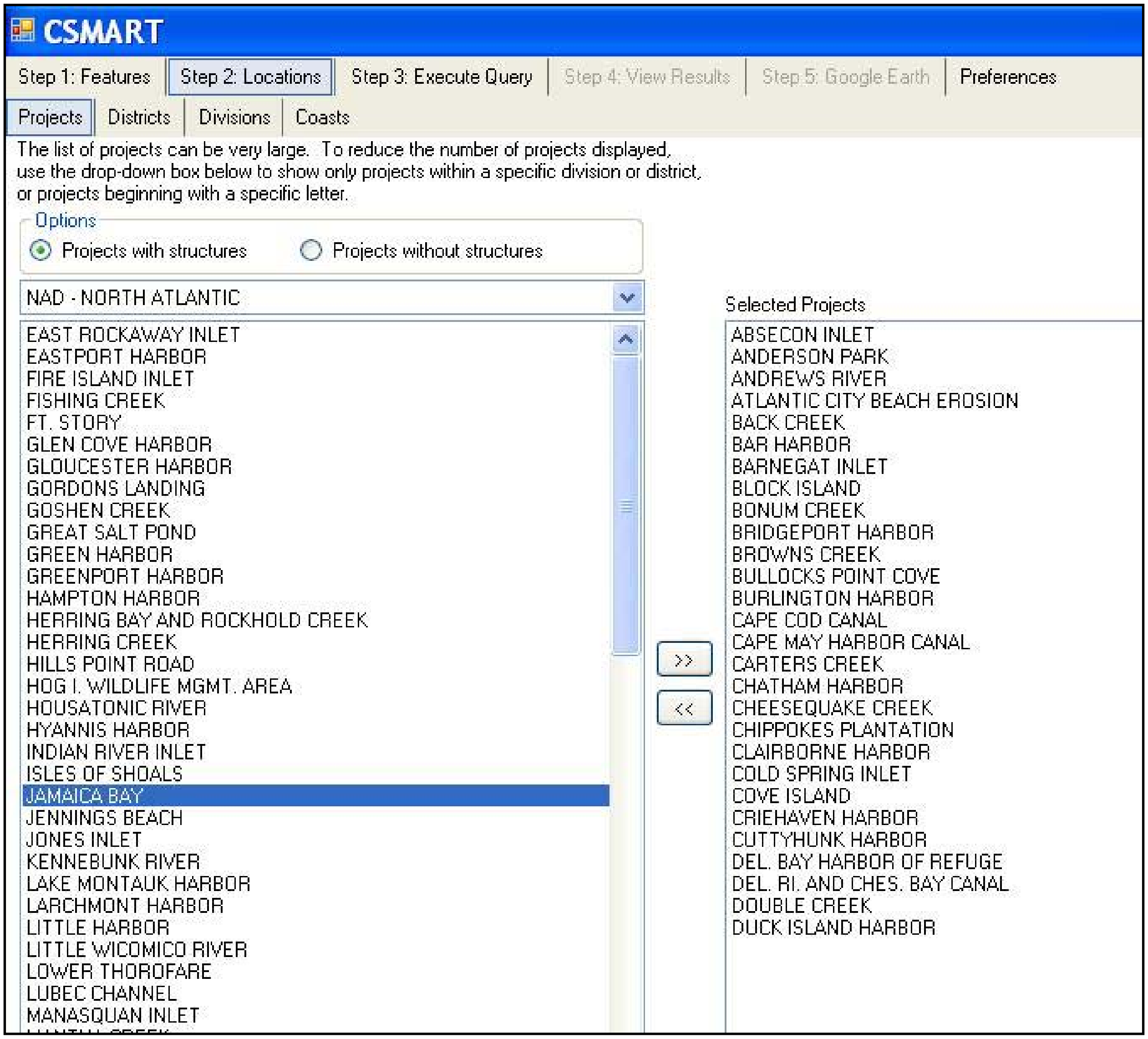
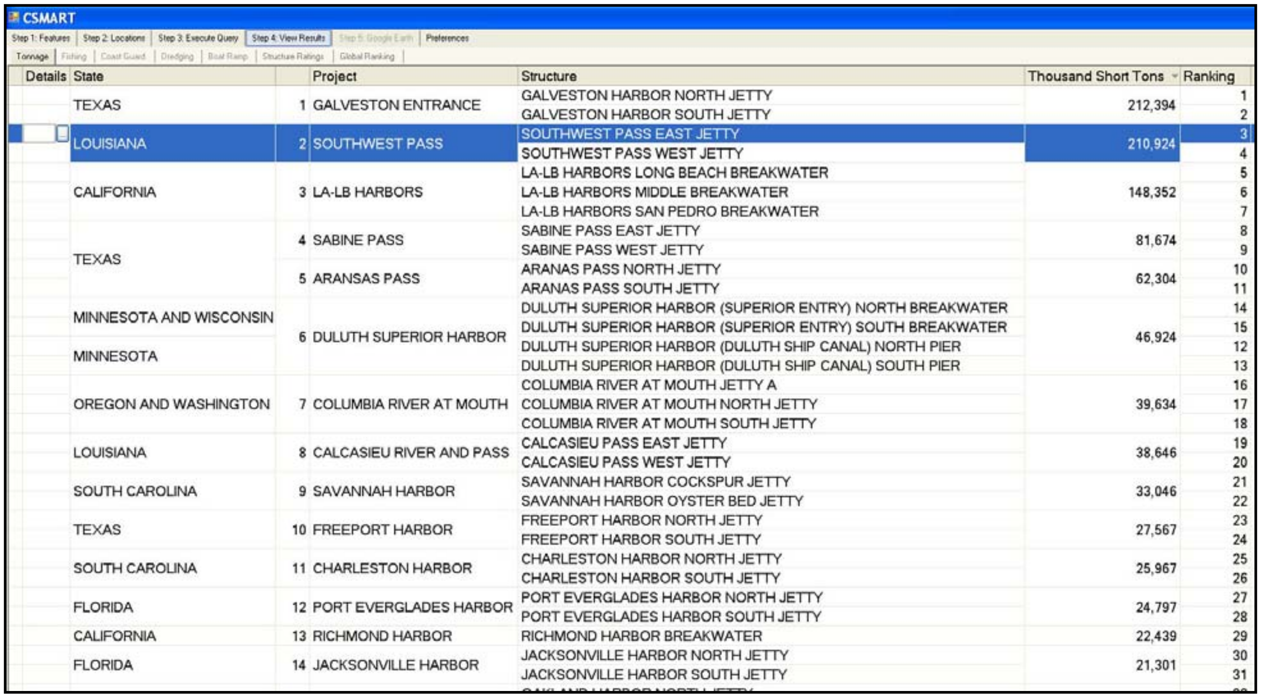


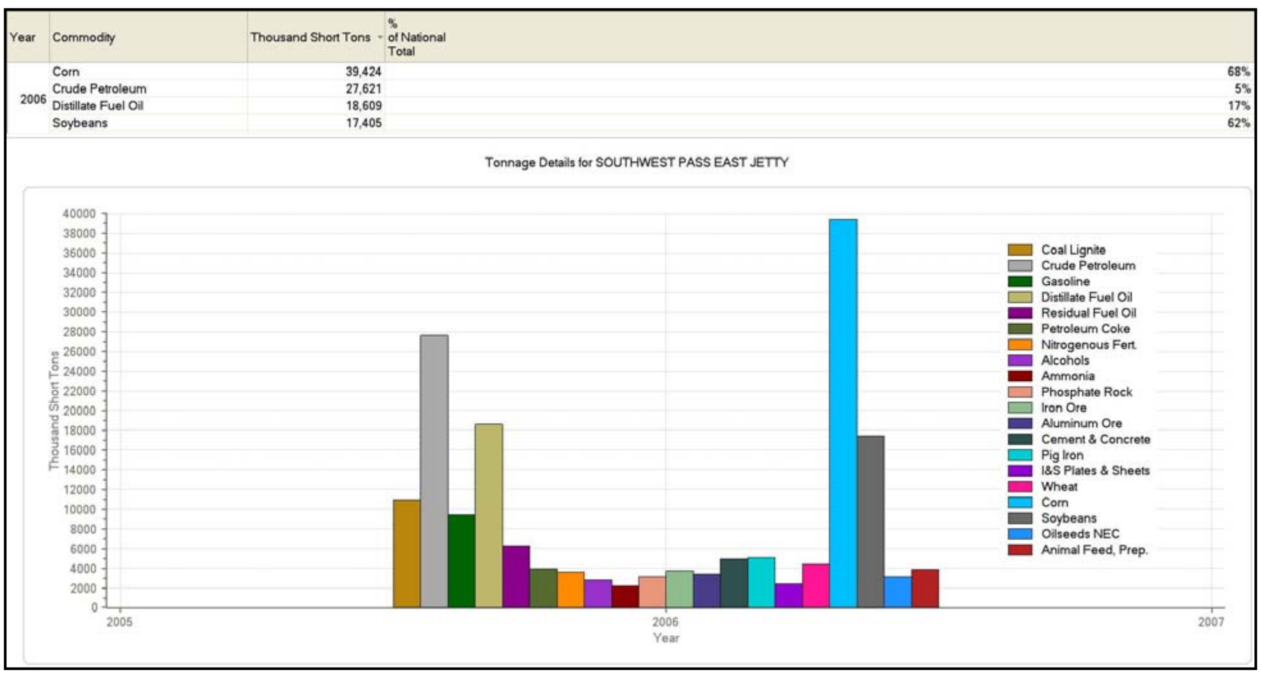
Figure 3. CSMART interface for selecting coastal structures.



CSMART
Step 1: Features | Step 2: Locations | Step 3: Execute Query | Step 4: View Results | Step 5: Google Earth | Preferences
Tonnage | Fishing | Coast Guard | Dredging | Boat Ramp | Structure Ratings | Global Ranking

Details	State	Project	Structure	Thousand Short Tons	Ranking
	TEXAS	1 GALVESTON ENTRANCE	GALVESTON HARBOR NORTH JETTY	212,394	1
			GALVESTON HARBOR SOUTH JETTY		2
	LOUISIANA	2 SOUTHWEST PASS	SOUTHWEST PASS EAST JETTY	210,924	3
			SOUTHWEST PASS WEST JETTY		4
	CALIFORNIA	3 LA-LB HARBORS	LA-LB HARBORS LONG BEACH BREAKWATER	148,352	5
			LA-LB HARBORS MIDDLE BREAKWATER		6
			LA-LB HARBORS SAN PEDRO BREAKWATER		7
	TEXAS	4 SABINE PASS	SABINE PASS EAST JETTY	81,674	8
			SABINE PASS WEST JETTY		9
		5 ARANSAS PASS	ARANAS PASS NORTH JETTY	62,304	10
			ARANAS PASS SOUTH JETTY		11
	MINNESOTA AND WISCONSIN	6 DULUTH SUPERIOR HARBOR	DULUTH SUPERIOR HARBOR (SUPERIOR ENTRY) NORTH BREAKWATER	46,924	14
			DULUTH SUPERIOR HARBOR (SUPERIOR ENTRY) SOUTH BREAKWATER		15
	MINNESOTA		DULUTH SUPERIOR HARBOR (DULUTH SHIP CANAL) NORTH PIER		12
			DULUTH SUPERIOR HARBOR (DULUTH SHIP CANAL) SOUTH PIER		13
	OREGON AND WASHINGTON	7 COLUMBIA RIVER AT MOUTH	COLUMBIA RIVER AT MOUTH JETTY A	39,634	16
			COLUMBIA RIVER AT MOUTH NORTH JETTY		17
			COLUMBIA RIVER AT MOUTH SOUTH JETTY		18
	LOUISIANA	8 CALCASIEU RIVER AND PASS	CALCASIEU PASS EAST JETTY	38,646	19
			CALCASIEU PASS WEST JETTY		20
	SOUTH CAROLINA	9 SAVANNAH HARBOR	SAVANNAH HARBOR COCKSPUR JETTY	33,046	21
			SAVANNAH HARBOR OYSTER BED JETTY		22
	TEXAS	10 FREEPORT HARBOR	FREEPORT HARBOR NORTH JETTY	27,567	23
			FREEPORT HARBOR SOUTH JETTY		24
	SOUTH CAROLINA	11 CHARLESTON HARBOR	CHARLESTON HARBOR NORTH JETTY	25,967	25
			CHARLESTON HARBOR SOUTH JETTY		26
	FLORIDA	12 PORT EVERGLADES HARBOR	PORT EVERGLADES HARBOR NORTH JETTY	24,797	27
			PORT EVERGLADES HARBOR SOUTH JETTY		28
	CALIFORNIA	13 RICHMOND HARBOR	RICHMOND HARBOR BREAKWATER	22,439	29
	FLORIDA	14 JACKSONVILLE HARBOR	JACKSONVILLE HARBOR NORTH JETTY	21,301	30
			JACKSONVILLE HARBOR SOUTH JETTY		31

Figure 4. CSMART tonnage ranking of coastal structures for 2006.



Year	Commodity	Thousand Short Tons	% of National Total
2006	Corn	39,424	68%
	Crude Petroleum	27,621	5%
	Distillate Fuel Oil	18,609	17%
	Soybeans	17,405	62%

Figure 5. CSMART chart showing commodity breakdown for the Southwest Pass jetties.

The tonnage details screen also contains a table showing the tonnage values for all commodities through Southwest Pass, as well as a percentage column which compares the tonnage value with the national total for each commodity. This is to help put the tonnage figures for each commodity into context and help convey the national significance of the structures in question. CSMART

allows the user to explore the rankings of structures according to each of the selected indicators of significance. In addition, as has been shown for commercial tonnage in Figure 5, individual structures may be analyzed further to see the details behind any particular indicator score. This feature lends transparency to the CSMART ranking framework, so that structures that rise unexpectedly to the top of a prioritized listing may be studied to determine the underlying reasons.

The final composite CSMART score for an individual structure is determined through a straightforward weighted summation of scores for the respective chosen indicators:

$$S_c = \sum_n i_n w_n \qquad (1)$$

where S_c is the composite CSMART score for a single structure, i_n is the score for the n-th indicator i, and w_n is the relative weighting assigned by the user to i_n. The indicator scores i_n are normalized based on the highest-scoring structure, and the relative weightings w_n are chosen such that they sum to 1.0. Therefore the highest possible composite score under this formulation is 1.0. Table 2 shows an example of the CSMART top 10 structures using this weighted summation approach; the chosen indicators and respective weightings are shown below the rankings.

Table 2. Sample CSMART composite rankings, top 10 structures.

Coastal Structure(s)	Rank	CSMART Score
Galveston Entrance jetties	1	.603
Columbia River Mouth jetties	2	.481
Fairport Harbor (Ohio) East Breakwater	3	.455
Tillamook Bay (OR) jetties	4	.451
Quillayute River (WA) jetties	5	.450
Southwest Pass jetties	6	450
LA-Long Beach breakwaters	7	.449
Humboldt Bay (CA) jetties	8	.409
Mission Bay (CA) Middle Jetty	9	.407
Lorain Harbor (OH) West Breakwater	10	.407

(Indicator weightings: Commercial tonnage – 40%; Structure Condition – 40%; Commercial Fishing – 10%; Subsistence Harbor Status– 5%; Harbor of Refuge Status – 5%)

These results show how CSMART allows the user to compare structures against others in different project, Districts, and Divisions, and how through a simple weighting process, smaller structures and projects (at least in terms of total project tonnage) can nonetheless rise near the top of the prioritized listings. In this example, commercial tonnage and structure condition ratings are given equal weighting, with modest weightings assigned to the other three indicators. It is interesting to note that even using these modest weightings both Tillamoook Bay and the Quillayute River, projects without any commercial tonnage on record, are still included in the top 10 nationally.

In the case of two jetties protecting an entrance channel, note that CSMART assigns an equal score to each for the various indicators chosen by the user. The only exception to this is if condition inspection results returned by the District show the jetties to be in significantly different physical conditions. In Table 2, individual breakwaters are shown for Fairport and Lorain Harbors because those individual structures were rated by the Buffalo District as being in poor physical condition relative to others within the same project. In the case of the LA-Long Beach breakwaters, CSMART considers all three of them to support the tonnage at the port equally, and the Los Angeles District reported all three with the same physical condition rating.

EXAMPLE FOR DIVISION-LEVEL PRIORITIZATION: To help demonstrate the applicability of CSMART at all levels of Corps management, an example is presented in Table 3 showing the top 10 structures just from within LRD.

Table 3 – Sample CSMART output for LRD coastal structures

Coastal Structure(s)	Rank	CSMART Score
Duluth-Superior Harbor, Duluth Entrance (MN) piers	1	.600
Fairport Harbor (OH) East Breakwater	2	.523
Cleveland Harbor (OH) Arrowhead Breakwaters and West Pier and West Breakwater	3	.506
Duluth-Superior Harbor, Superior Entrance (WI) breakwaters	4	.500
Lorain Harbor (OH) West Breakwater	5	.434
Fairport Harbor (OH) West Breakwater	6	.423
Oswego Harbor (NY) West Arrowhead Breakwater	7	.406
Keweenaw Waterway (MI) Lower Entrance Breakwater	8	.400
Milwaukee Harbor (WI) North Breakwater	9	.331
Indiana Harbor (IN) Breakwaters	10	.320
(Indicator weightings: Commercial tonnage – 40%; Structure Condition – 40%; Subsistence Harbor Status– 10%; Harbor of Refuge Status – 10%)		

In this case, commercial fishing has been left out of the formulation, and the weightings for Harbor of Refuge status and Subsistence Harbor status have been shifted accordingly. The results of this CSMART ranking may seem counterintuitive at first, since structures at Fairport and Lorain, top 10 structures in the national ranking shown in Tab. 2, are not the top 2 structures when looking at just LRD. This is due to the normalized indicator scores presently used by CSMART; at the national level, the extremely high tonnage levels at the Galveston Entrance, Southwest Pass, and elsewhere have the effect of reducing the relative tonnage scores for mid-sized ports such as Duluth-Superior. However, when one considers only the structures within LRD, the larger Great Lakes ports tend to have higher relative tonnage scores and therefore move higher in the overall rankings. This issue highlights yet another reason for tools such as CSMART to be adopted into Corps business practice, namely, the need to document and report on the various sources of information that drive investment decisions. All of the rankings tables produced by CSMART can be easily exported as simple text files or as Microsoft Excel spreadsheets. Likewise, the various breakdown charts (such as that seen in Fig. 5) can also be easily copied to the clipboard or saved as image files. These features enable Corps decision makers to include supporting documentation as part of upward reporting activities to provide transparency and defend budgetary requests.

FUTURE CSMART UPGRADES: In addition to migrating the application to a web-based environment and merging the interface with that of CPT, planned enhancements to CSMART include improved Google Earth visualizations of the results and additional data sets so that more indicators of significance can be factored into the final rankings.

Improved Google Earth visualizations: CSMART presently features a demonstration-level capability for producing .kml files for viewing of output within the Google Earth application. Improvement plans for this capability call for additional visualization aids, such as color-coding and variable-sized icons to help convey structure significance. Example screen captures showing data used by CSMART are shown in Figures 6 and 7.

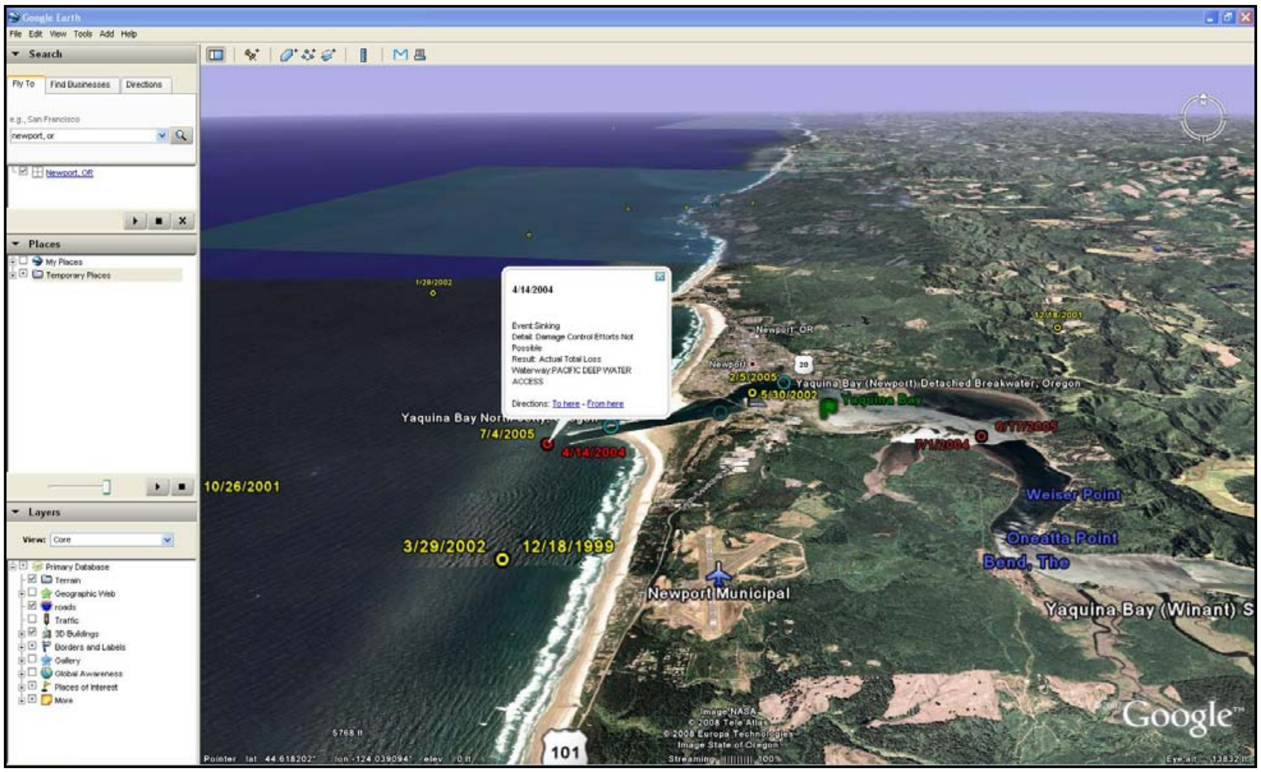


Figure 6. Example Google Earth view of Coast Guard incidents near Yaquina Bay, OR.

USDOT Cruise Line Statistics: The Maritime Administration (MARAD) of the U.S. Department of Transportation (USDOT) collects and publishes statistics concerning commercial cruise lines operating in U.S. waters. The data are organized at the port level of detail, and can be found online here: *http://www.marad.dot.gov/documents/north_america_cruise_detail_data.xls*. These data can be easily associated with supporting coastal structures and used as another indicator of economic significance.

USDOT Ferry Passenger Statistics: There are hundreds of ferry services operating throughout U.S. waters, many of them dependent upon USACE coastal structures for protection from wave and adverse currents. Statistics concerning commercial ferries in the U.S. are found through the Bureau of Transportation Statistics, a branch of the USDOT. An online database providing information such as number of passengers and number of vehicles transported can be

found here: *http://www.transtats.bts.gov/Tables.asp?DB_ID=616&DB_Name=National%20Census%20of%20Ferry%20Operators&DB_Short_Name=Ferry%20Census*

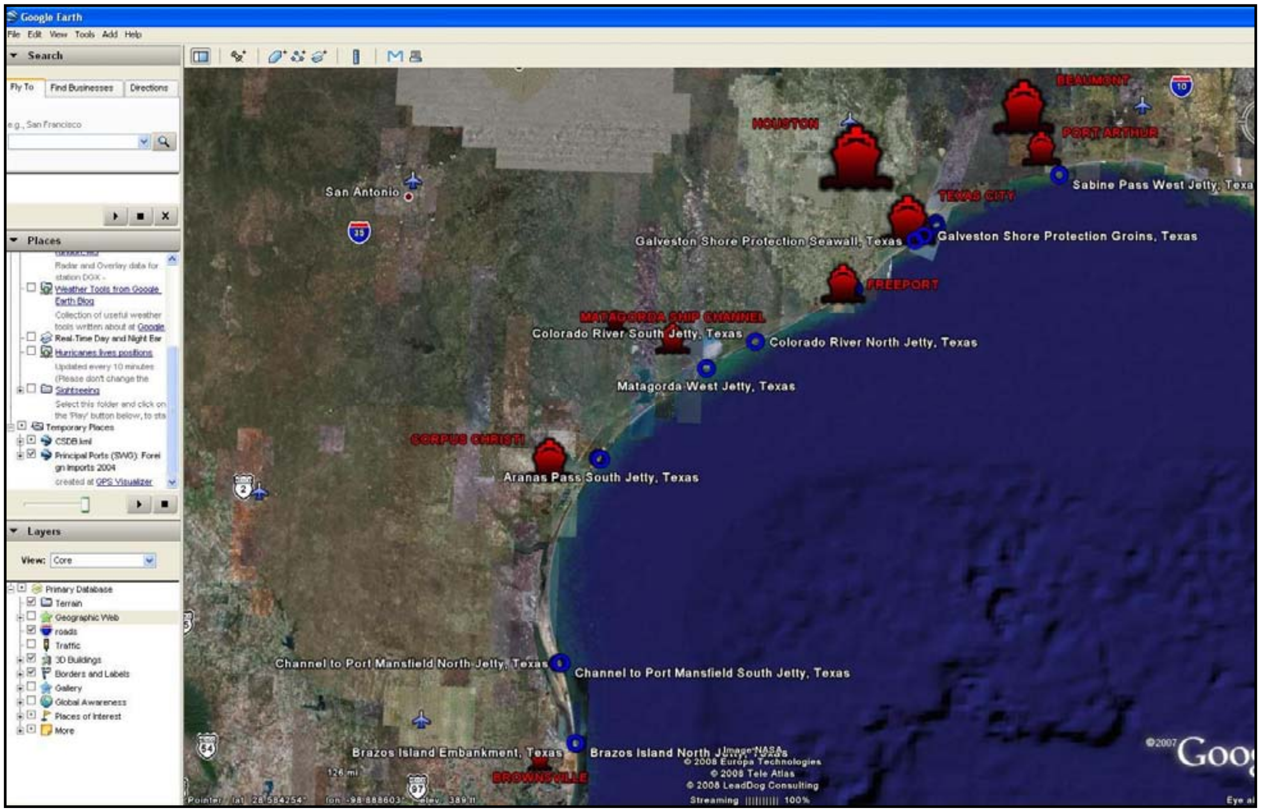


Figure 7. Example Google Earth showing relative tonnage of Texas coastal ports.

NDC Port Facilities Database: The NDC maintains a US port facilities database which provides detailed summaries of nearly 10,000 individual port operations in roughly 200 different port areas. The docks and port facilities database is continuously updated, and can be found online here: *http://www.iwr.usace.army.mil/ndc/ports/ports.htm*. These reports provide detailed descriptions for a wide variety of port facilities, including oil refineries and storage terminals, grain storage silos, aggregates storage and processing facilities, chemical plants and handling facilities, container handling facilities, recreational marinas, passenger ferry terminals, steel and aluminum plants, marine science and research institutes, U.S. Coast Guard facilities, and seafood processing facilities. It is thought that associating these facilities with nearby coastal structures helps to give an idea of the importance of that structure to the local, regional, and perhaps national transportation infrastructure.

SUMMARY: This CHETN provides a description of and context for the CSMART decision-support software package developed within the Coastal Navigation Portfolio Management (CNPM) work unit of the CIRP. The software is intended to provide a means for Corps decision makers to prioritize coastal jetty and breakwater structures for annual O&M funding. Refinements and upgrades to the CSMART application are ongoing, and efforts of the CNPM work unit will continue towards implementation of the asset management philosophy within the USACE navigation business line.

POINT OF CONTACT: This CHETN is a product of the Coastal Navigation Portfolio Management Work Unit of the Coastal Inlets Research Program (CIRP) being conducted at the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory. Questions about this technical note can be addressed to Dr. Ned Mitchell (Phone: 601-634-2022, e-mail: *kenneth.n.mitchell@usace.army.mil*). For information about the Coastal Inlets Research Program (CIRP), please contact the CIRP program manager, Dr. Julie D. Rosati, at 251-694-3719 or *julie.d.rosati@usace.army.mil*. This technical note should be cited as follows:

> Mitchell, K. N. 2010. *A review of coastal navigation asset management efforts within the coastal inlets research program (CIRP): Part 1: Coastal structures*. ERDC/CHL CHETN-III-80. Vicksburg, MS: U.S. Army Engineer Research and Development Center. *http://chl.erdc.usace.army.mil/chetn*

REFERENCES

U.S. Army Corps of Engineers Asset Management Plan. 2008 Headquarters, U.S. Army Corps of Engineers. Washington, DC. *https://corpsglobeweb.usace.army.mil/assetmanagement/documents/amp0809.pdf*

Bottin, R., and F. Sargent. 1988 Case histories of Corps breakwater and jetty structures. Vicksburg, MS: U.S. Army Engineer Waterways Experiment Station. *http://chl.erdc.usace.army.mil/chl.aspx?p=s&a=ARTICLES;449*

Government Accountability Office (GAO). 2008 *Federal user fees: Substantive reviews needed to align port-related fees with the programs they support*. GAO-08-321. *http://www.gao.gov/new.items/d08321.pdf*

Hughes, S., and N. Kraus. 2006. *Frequently-Asked Questions (FAQs) About Coastal Inlets and U.S. Army Corps of Engineers' Coastal Inlets Research Program (CIRP).* Coastal and Hydraulics Laboratory Engineering Technical Note. ERDC/CHL CHETN-IV-67. *http://cirp.usace.army.mil/pubs/chetns/CHETN-IV-67.pdf*

Mitchell, K. 2009. Depth-utilization analysis for estimating the economic activity supported by dredging. *Terra et Aqua*. International Association of Dredging Companies. *http://cirp.usace.army.mil/pubs/pdf/mitchell_terra-et-aqua09.pdf*

Transportation Research Board. 2004. *The Marine Transportation System and the Federal Role: Measuring Performance, Targeting Improvement*. Washington, DC: National Academy of Sciences. *http://onlinepubs.trb.org/onlinepubs/sr/sr279.pdf*

O'Keefe, S., and M. Downey et al. 2007. *Prioritizing America's Water Resources Investments: Budget Reform for Civil Works Construction Projects at the U.S. Army Corps of Engineers*. Washington, DC: National Academy of Public Administration. *http://www.napawash.org/pc_management_studies/Corps_Summary_Report_03-02-07.pdf*